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UAV による棚田の植生及び灌漑調査

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SURVEY ON THE VEGETATION COVER AND IRRIGATION FOR RICE TERRACE WITH UAV

by

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Recently, UAV (Unmanned Aerial Vehicle) technology has been developed rapidly. UAV allows engineers to use remote sensing at lower cost than satellite images or aerial photos. The expansion of business for UAV is expected. However, UAV can take photos in local areas, not the global area. Then the authors covered areas without pictures by UAV using aerial photograph from aircrafts. The objectives of this study were to identify possibilities for remote sensing with three types of photography (aerial photographs, panoramic photographs, and UAV photographs) and to monitor vegetation covers. The data were processed through five main steps: (1) to obtain aerial photographs in research sites from Geographical Survey Institute, (2) to take pictures with digital camera in 360 degrees in research sites, (3) to flow UAV with two filters, IR72 and IR90 in research sites, (4) to construct a 3D model in research sites with PhotoScan, and (5) to analyze vegetation covers with GIS.

Key words: *Cumulative flows, Infrared, Panorama, Watershed*

1. Introduction

The modern remote sensing has been developed. In 1858, Tournachon, a balloonist took photographs in Paris from his balloon. In World War I, aerial photograph technology was the most advanced for military purpose. In the latter half of the twentieth century, it was possible to use remote sensing all over the world with satellites. Moreover, new aeronautical technology, UAV would develop remote sensing.

Also, the authors made a 3D model from UAV photogrammetry with PhotoScan, Professional. PhotoScan is a software that creates a 3D model with high resolution. In general, UAV has a wide-angle lens with lens distortion. PhotoScan corrects automatically the distortion with a correction algorithm. Moreover, PhotoScan allowed to export orthogonal photos including GPS (Global positioning system) coordinates and DEM (Digital elevation model), and also to calculate NDVI and another normalized vegetation index, NDWI.

Incidentally, the authors utilized data obtained from remote sensing as broadband data for GIS (Geographic Information System). Orthogonal photos were analyzed with ArcGIS for terrain analysis.

In paddy cultivation, an irrigation system is more important than flat rice fields. Terraced paddy fields have been abandoned for an acreage-reduction policy since 1970s. Now, 40% of terraced paddy fields are abandoned. Abandoned rice fields are a serious problem. After 1990, some activities are done to protect paddy fields. In 1992, "Rice terrace order system", the resident of a city experience rural lives with farmers, started. In 1995, “Rice terrace summit” started to inform necessity for preservation of rice fields and to obtain understanding and agreements. In 1999, the Ministry of Agriculture, Forestry and Fisheries evaluated rice fields to preserve.

Onigi terraced rice fields was developed in the Edo era and had some functions: flood disaster prevention, water

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retention, and landslide prevention.

2. Methods

2.1 Photographing methods with UAV

Phantom 4.0 Professional was used in this research. First, UAV was flown in the survey field. Next, a filter, IR72 was set on UAV camera to obtain NDVI. Finally, a list of bands in this study is shown in Table 1.

Table 1 List of bands

Band	Wave length(nm)	Electric Magnetic Wave
1	450-520	Blue
2	520-600	Green
3	630-690	Red
4	760-900	Near Infrared
5	900-	Short Infrared

2.2 Photograph methods with digital camera

Nikon D5500 was used in this research. The photographs were processed through two steps: (1) to take a picture without a filter and (2) with a filter, IR72 for NDVI.

2.3 3D modeling with PhotoScan

A high-density cloud was constructed from UAV photogrammetry and GPS (Global Positioning System) coordinates with Agisoft, PhotoScan, Professional. Furthermore, constructing meshes and textures made a 3D model. Also lens distortion was corrected with the correction algorithm in PhotoScan. In the same way, 3D models were made from aerial photographs.

2.4 Methods for orthogonal photos with PhotoScan

Orthogonal photos were made from a 3D model with PhotoScan Professional. Furthermore, orthogonal photos with 3D data were made by exporting in TIFF file format.

2.5 Calculation of NDVI with Photoshop

NDVI was calculated with Adobe, Photoshop CS6 by subtracting orthogonal photos in Band 3 from orthogonal photos in Band 4 at the same position. NDVI is shown as next.

$$\mathrm{NDVI} = \frac{Band4 - Band3}{Band4 + Band3} \qquad (1)$$

2.6 Calculation of NDWI with Photoshop

NDWI was calculated with Photoshop CS6 by subtracting orthogonal photos in Band 3 from orthogonal photos in Band 5 at the same position. NDWI is shown as next.

$$\mathrm{NDWI} = \frac{Band3 - Band5}{Band3 + Band5} \qquad (2)$$

2.7 Methods for calculating a catchment area

Surfaces were smoothed from DEM (Digital Elevation Model) in a 3D model with ESRI, ArcGIS. Furthermore, flow direction raster and cumulative-flow-rate value raster were made from DEM (Digital Elevation Model). Finally, catchments were calculated with flow-direction raster and cumulative flow-rate-value raster with ArcGIS.

2.8 Methods for detecting land-use maps.

Band 3 distributions were calculated in the survey field with PhotoScan. Band 3 distribution could make land-use maps because vegetation absorbed Band 3, red.

3. Results and Discussion

On 30 July 2016, the aerial photos were taken with Phantom 4.0 at Onigi village, Hasami town in Nagasaki prefecture. The objectives of this field work were to make a 3D model and orthogonal photos to estimate NDVI, to calculate catchments, and to make land-use maps

Fig. 1 Orthogonal image with aerial photos at Onigi village

Fig. 1 shows an orthogonal image with aerial photos at Onigi village. The orthogonal photo covered a wide investigation area.

Fig. 2 Study area with UAV (in red lines)

Fig. 2 shows an investigation area with UAV (in a red line) in Onigi village. In this research, UAV was flown from two different spots in one hour.

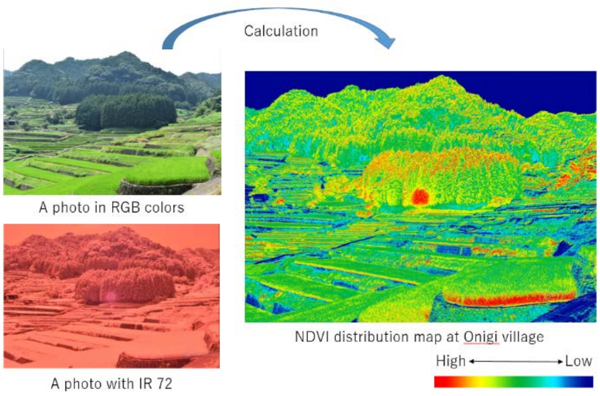

Fig. 3(a) NDVI at Onigi village

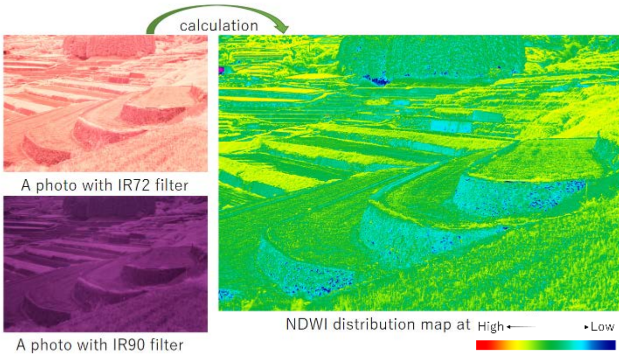

Fig. 3(b) NDWI at Onigi village (May 8 2016)

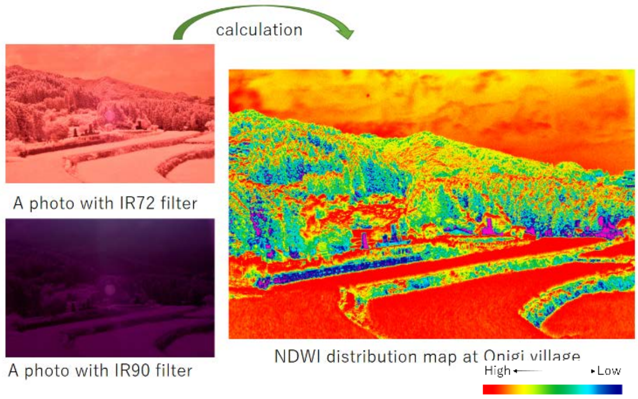

Fig. 3(c) NDWI at Onigi village (July 30 2016)

Fig. 3(a) shows NDVI distributions in Onigi Village. NDVI indicated equally medium in paddy fields. NDVI was low in paddy fields that have been abandoned and are no longer cultivated. NDVI became medium or high in tea plantations.

Fig. 3(b) shows NDWI distributions in Onigi Village in May 8, 2016. NDWI indicated medium in paddy fields because the rice planting did not start. NDWI was medium in paddy fields that have been abandoned and are no longer cultivated. NDWI became low at the stone walls.

Fig. 3(c) shows NDWI distributions in Onigi Village in July 30, 2016. NDWI was equally high in paddy fields because vegetation evaporated vapor. NDWI showed medium in paddy fields that have been abandoned and are no longer cultivated. NDWI became low in at the stone walls.

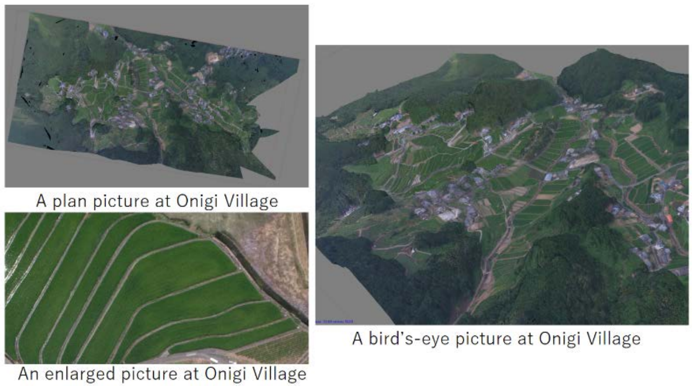

Fig. 4(a) 3D models at Onigi village

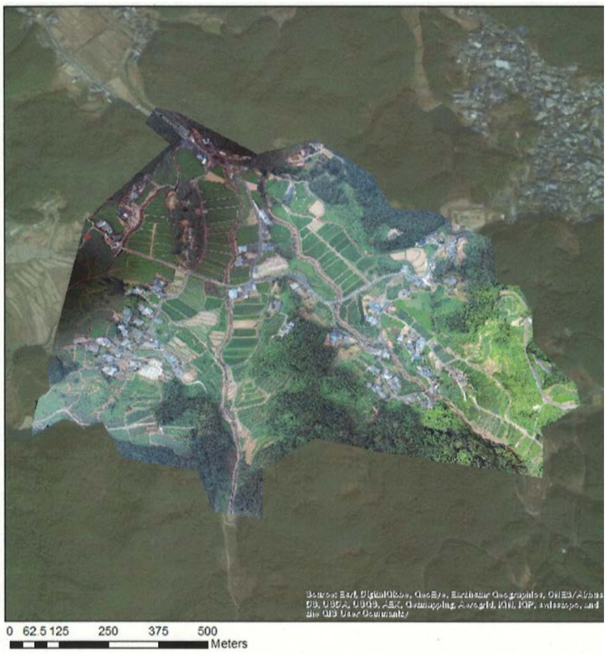

Fig. 4(b) Orthogonal map at Onigi village

Figs. 4(a) and (b) show 3D models at Onigi village and an orthogonal map at Onigi village respectively. 179 pictures were taken with UAV from two different spots. A 3D model was made at Onigi village. The spatial resolution was 12.2 cm/pix. The study area was 1.73 km^2. Also, pictures were taken with IR72 filter. But, IR72 photos were not clear because it was dark. Unclear images could synthesize UAV photogrammetry and to make a 3D model with IR72.

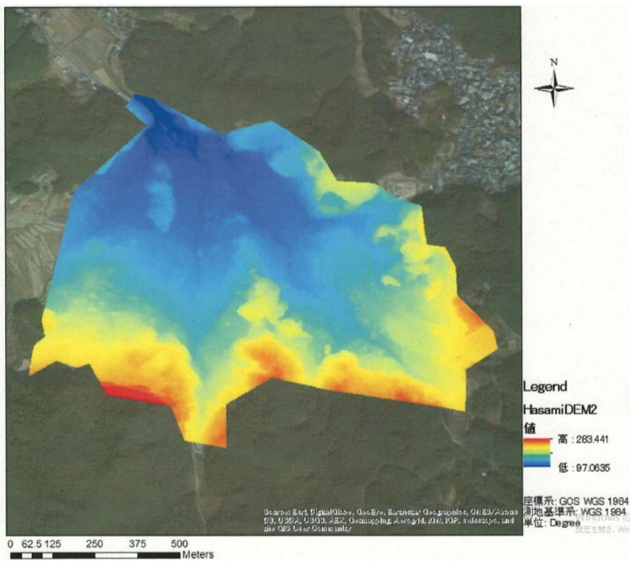

Fig. 5(a) DEM at Onigi village

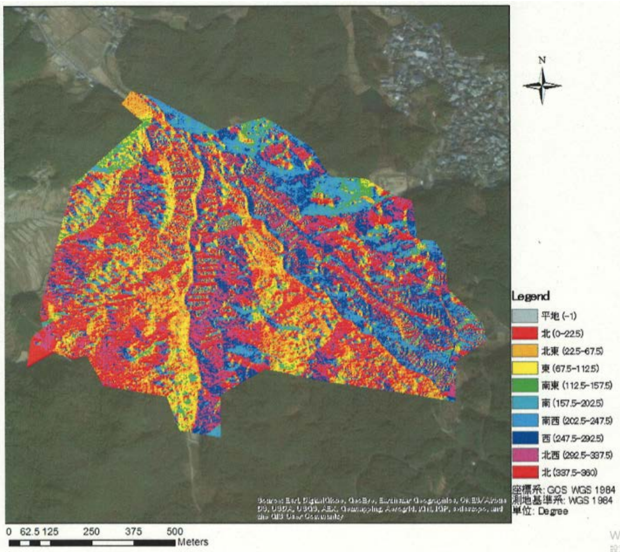

Fig. 5(b) Direction of drips at Onigi village

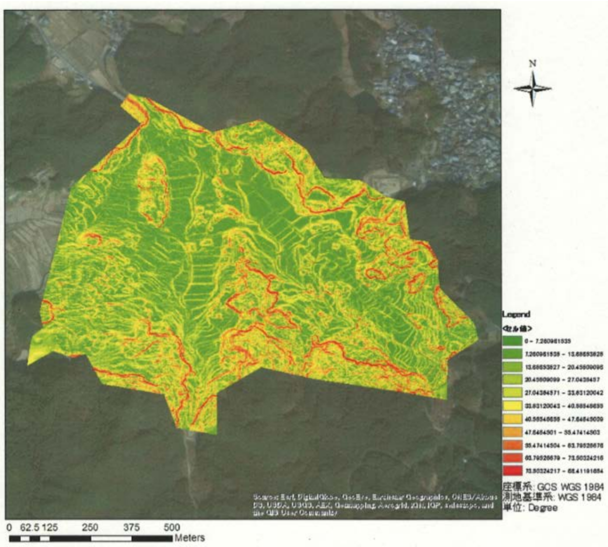

Fig. 5(c) Angle of slope at Onigi village

Fig. 5(a) shows a DEM of Onigi village. Fig. 5(b) shows a direction of drips at Onigi village. Fig. 5(c) shows Angle of slope at Onigi village. The DEM of Onigi village has high resolution and the DEM point density was 4.2 m^{-2}. According to Fig. 5(b), a direction of drips at west Onigi village was in a northeast direction, while a direction of drips at east Onigi village was in a south direction. According to Fig. 5(c), a boundary was judged between paddy fields.

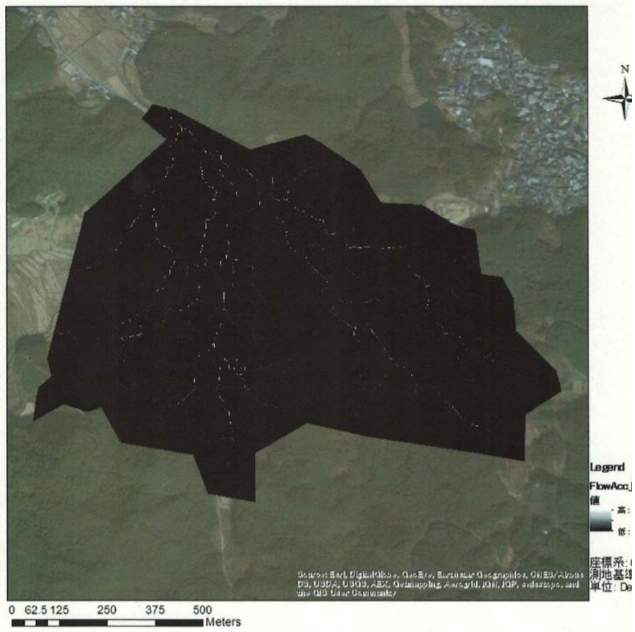

Fig. 6(a) Cumulative flows at Onigi village

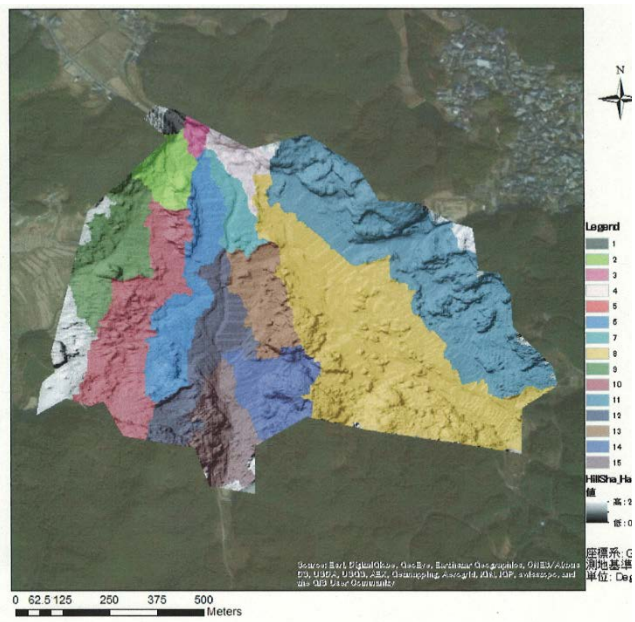

Fig. 6(b) Shaded-relief map and watershed at Onigi village

Figs. 6(a) and (b) show cumulative flows and a shaded-relief map and watershed in Onigi Village, respectively. Rivers were judged from cumulative flows and, also cumulative flows could estimate watershed.

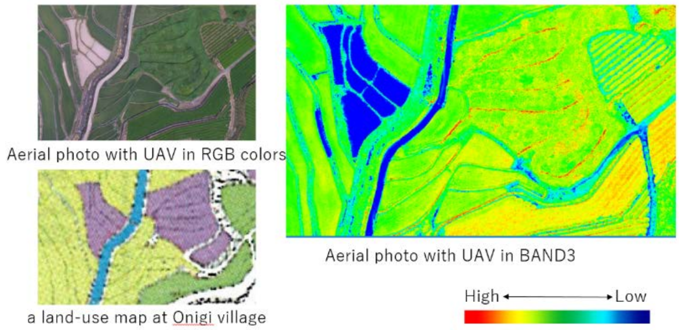

Fig. 7(a) Making a land use map at Onigi village

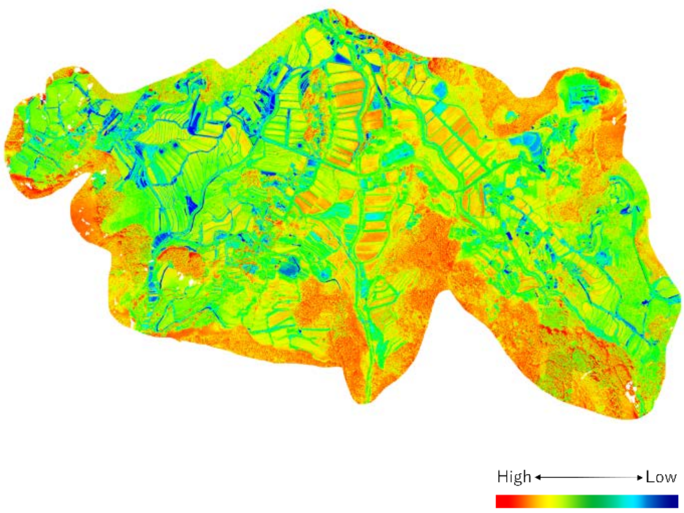

Fig. 7(b) Aerial photo with UAV in Band 3 at Onigi village

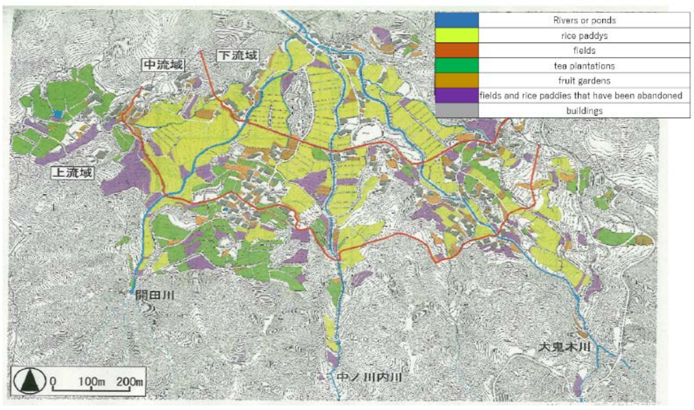

Fig. 7(c) Referenced land use map at Onigi village

Table 2 Legend for a land use map

(blue)	Rivers or ponds
(yellow-green)	rice paddys
(orange)	fields
(green)	tea plantations
(ochre)	fruit gardens
(purple)	fields and rice paddies that have been abandoned
(gray)	buildings

Figs. 7(a), (b), and (c) show making a referenced land-use map, an aerial photo with UAV in Band 3 at Onigi village, a land-use map in Onigi village. Table 2 shows a legend for a land use map. An aerial photo with UAV in Band 3 at Onigi village could judge land uses. According to Figs. 7(a), (b), and (c), rice fields showed green or yellow equally in Band 3 photo, paddy fields that have been abandoned and are no longer cultivated were blue or scattered green, red and yellow, and also tea plantations became red or yellow linearly.

4. Conclusions

Contemporary states of UAV and its applications for hydrology were discussed. The objectives of this study were to construct a 3D model, to make orthogonal photos, and to calculate NDVI, NDWI, and watershed from UAV photogrammetry. As a result, it was possible to obtain spatial data in higher resolution than satellite data. A camera of UAV has high performance. It works for remote sensing in any climates except heavy rain. Cloudy days could not take a picture with IR 72 filter because of lack of sunlight. Additionally, three-band photos could estimate a land-use map. Above all, the authors concluded that UAV would apply for many fields of hydrology at local areas.

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